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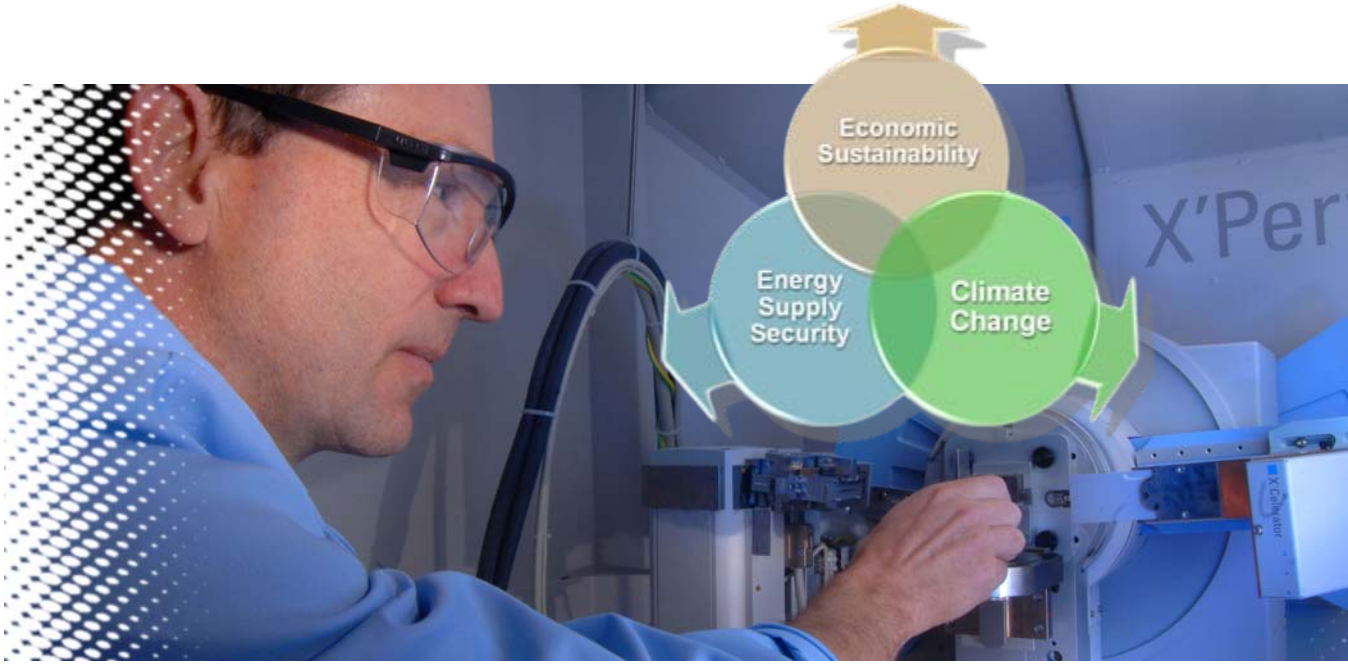

Modeling Material Flows and Greenhouse Gas Emissions in a PHEV-CCS-CO_2EOR System

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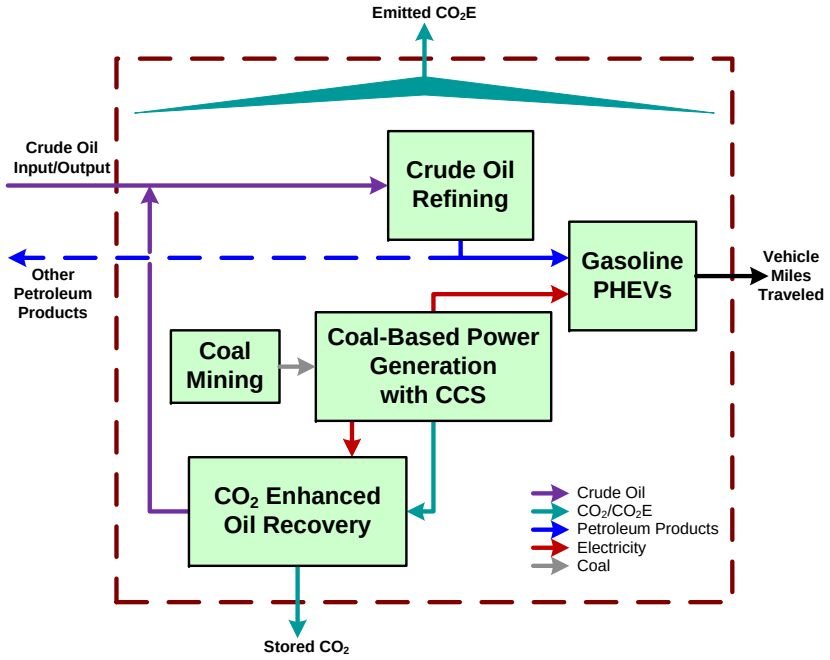
GHG Emissions PHEV Scenario Analysis Tool

- **Link:** http://www.netl.doe.gov/energy-analyses/pubs/PHEV-CO2EOR-CCS_12-16_CBTL.xls
- **Plug-in hybrid electric vehicles (PHEVs) are powered by a combination of electricity and liquid fuel (gasoline or diesel)**
- **NETL's tool models PHEVs powered by coal-fired power plants with carbon dioxide (CO_2) capture and storage (CCS) and either:**
  - Gasoline refined from crude oil
  - Diesel fuel produced from a coal and/or biomass to liquids (CBTL) plant with CCS
- **Each scenario allows use of the captured CO_2 in enhanced oil recovery (CO_2-EOR) for production of domestic crude oil**
- **The model determines the life cycle greenhouse gas (GHG) emissions in CO_2 equivalents (CO_2E) per vehicle mile traveled (VMT) and compares to a conventional vehicle powered solely by petroleum-based fuels**

Gasoline and Diesel Configurations

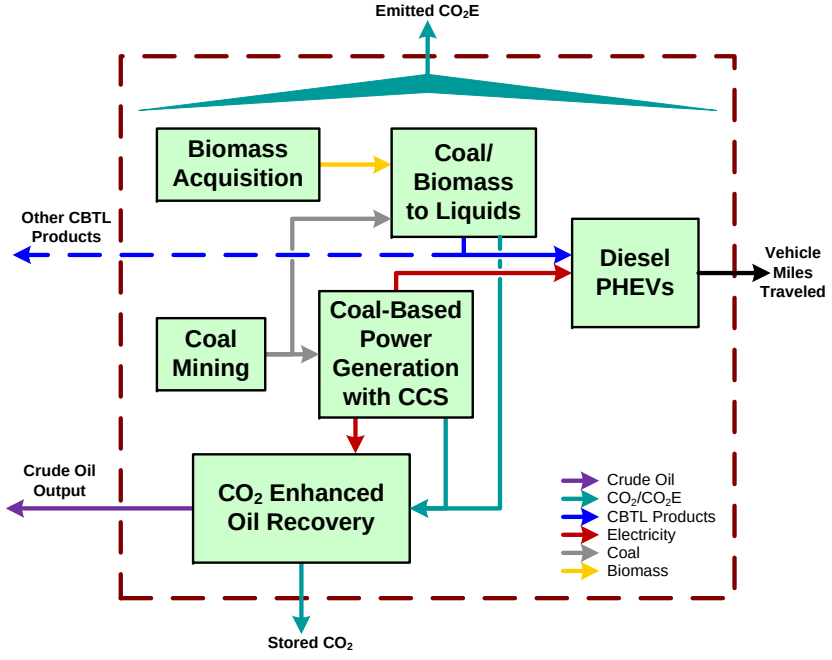
PHEV powered by GASOLINE refined from crude oil and electricity from a coal-based power plant with CCS

- ✓ *Significantly lower GHG emissions can be achieved relative to conventional gasoline-powered vehicles*
- ✓ *Many configurations result in a net output of domestic crude oil*



PHEV powered by DIESEL produced in a CBTL plant with CCS and electricity from a coal-based power plant with CCS

- ✓ *Significantly lower GHG emissions can be achieved relative to conventional diesel-powered vehicles*
- ✓ *All configurations result in a net output of domestic crude oil*

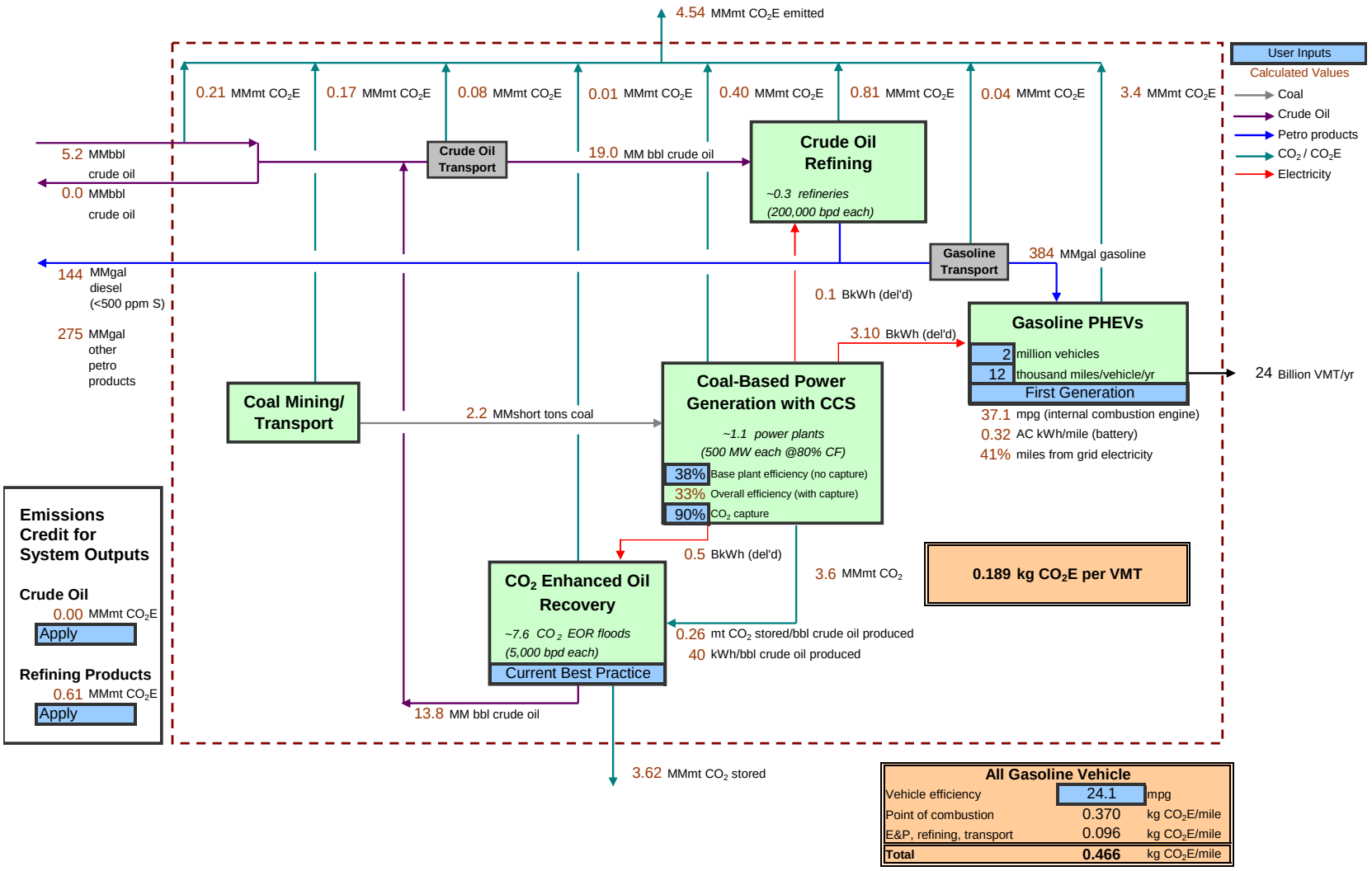


Technology Options and User Inputs

- **Pre-set technology levels and configurations available with description and data sources provided**
  - PHEV: 1st Generation, Advanced, Non-PHEV
  - CO_2-EOR: Current Best Practices, Next Generation and Second Generation, Sequestration Only
  - CBTL: up to 15% biomass and with or without auto thermal reforming (ATR)
- **User inputs for each sub-system are available throughout tool**
  - Power plant efficiency and CO_2 capture rates
  - PHEV performance parameters
  - CO_2-EOR performance parameters
  - CBTL and refinery performance parameters
  - Crude oil, coal and biomass acquisition parameters

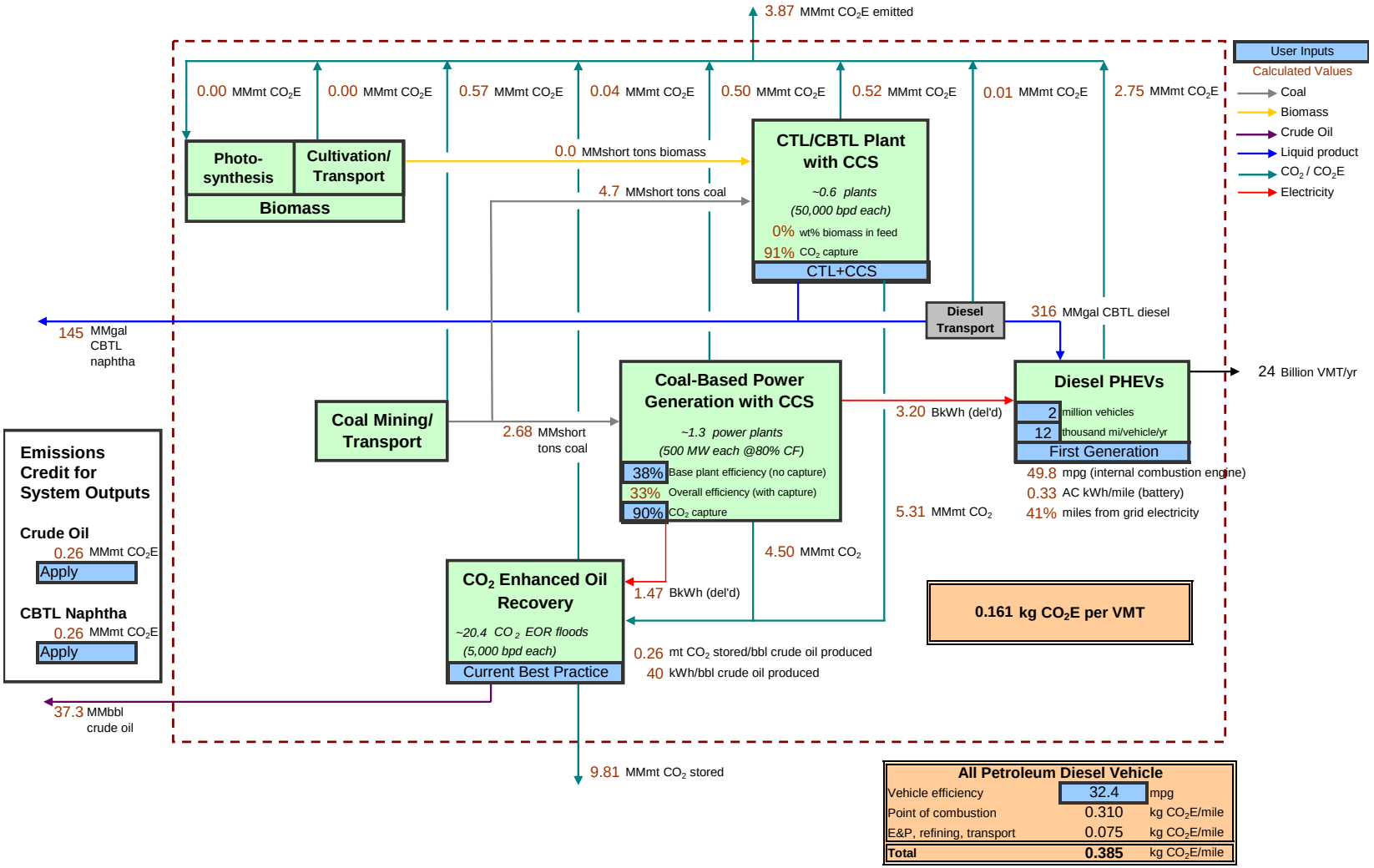
Snapshot of Tool – Petroleum Gasoline

Material flows in a gasoline PHEV system where captured CO_2 from power is used for CO_2 EOR

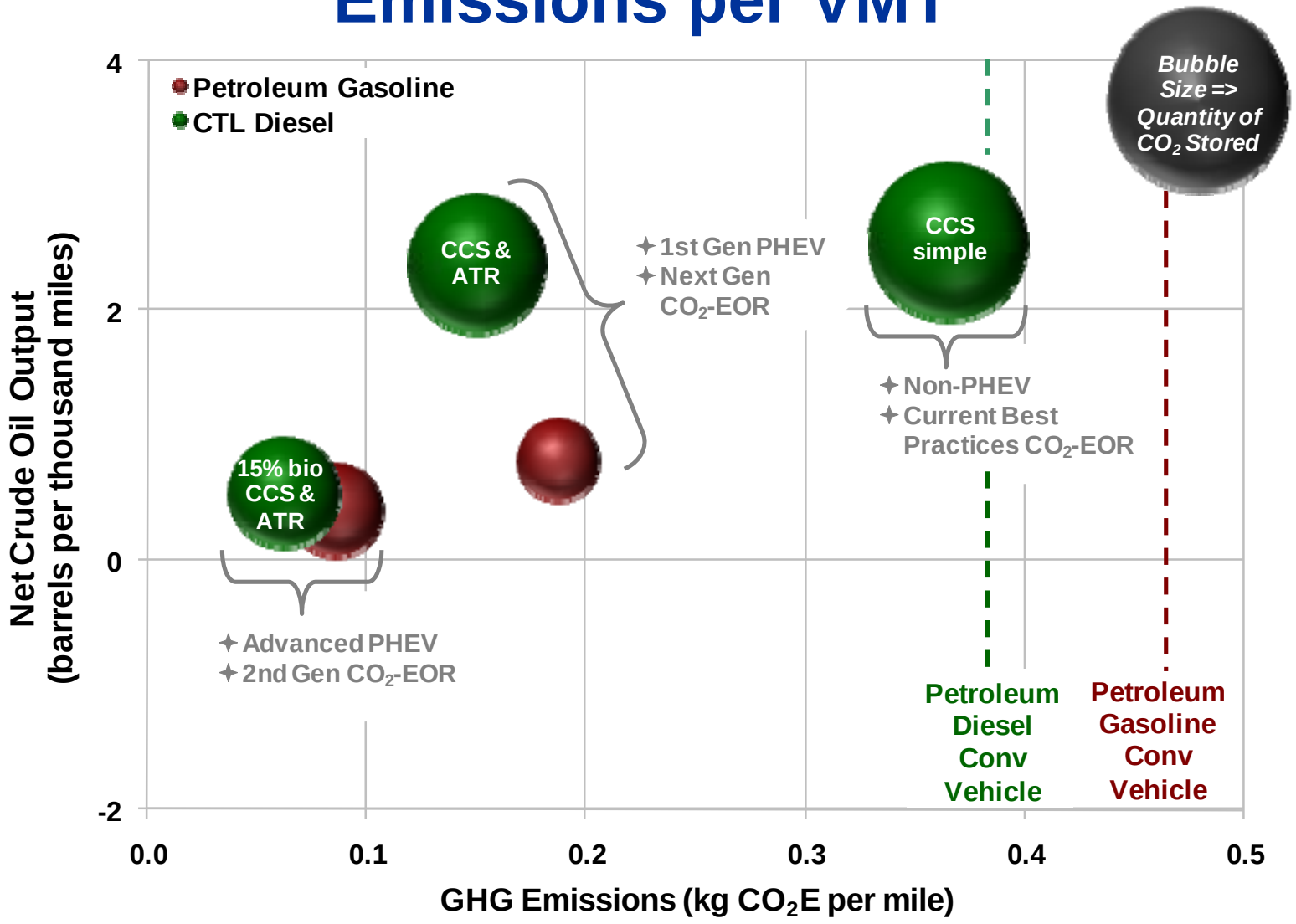


Snapshot of Tool – CBTL Diesel

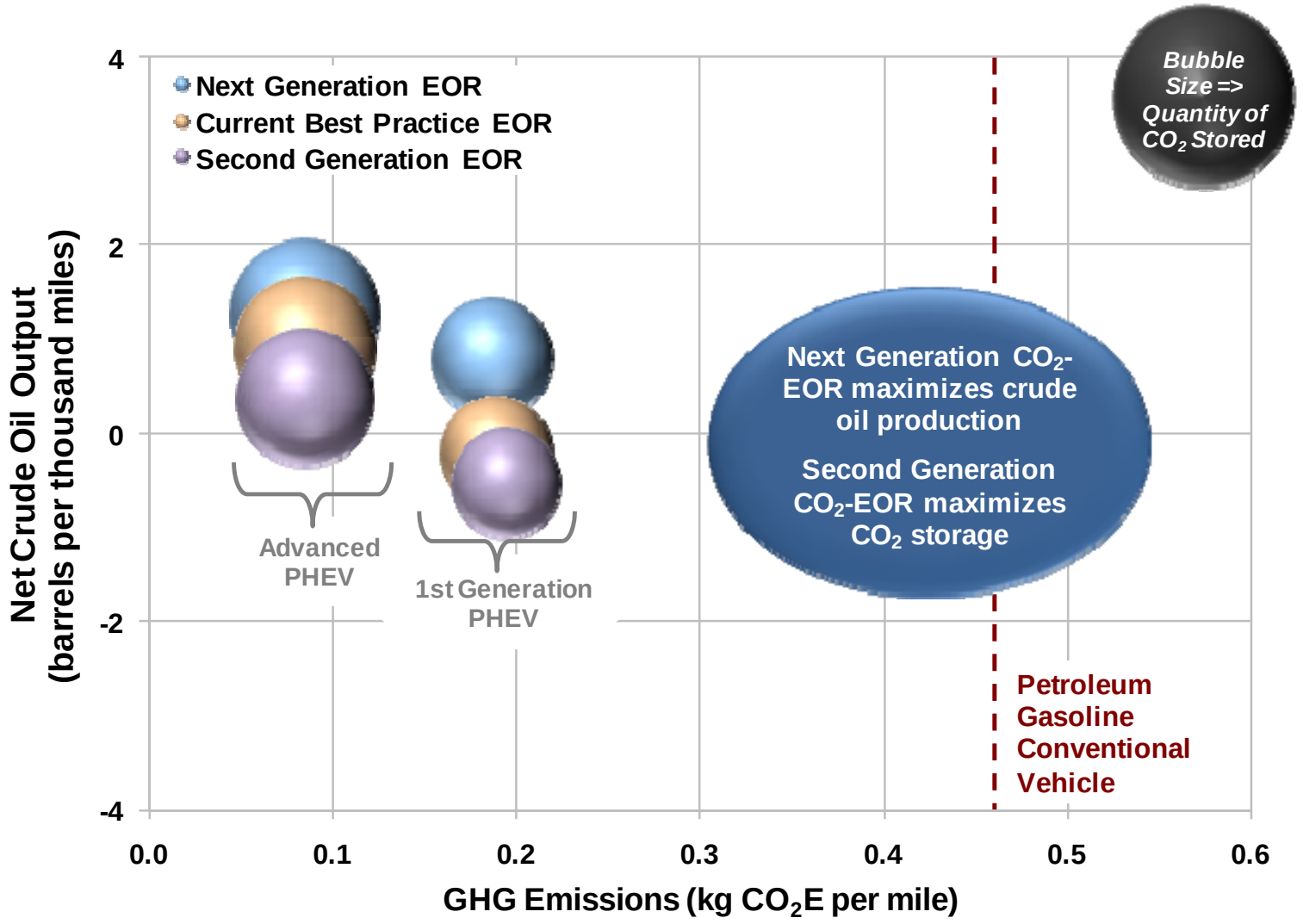
Material flows in a CBTL diesel PHEV system where captured CO_2 from power is used for CO_2 EOR



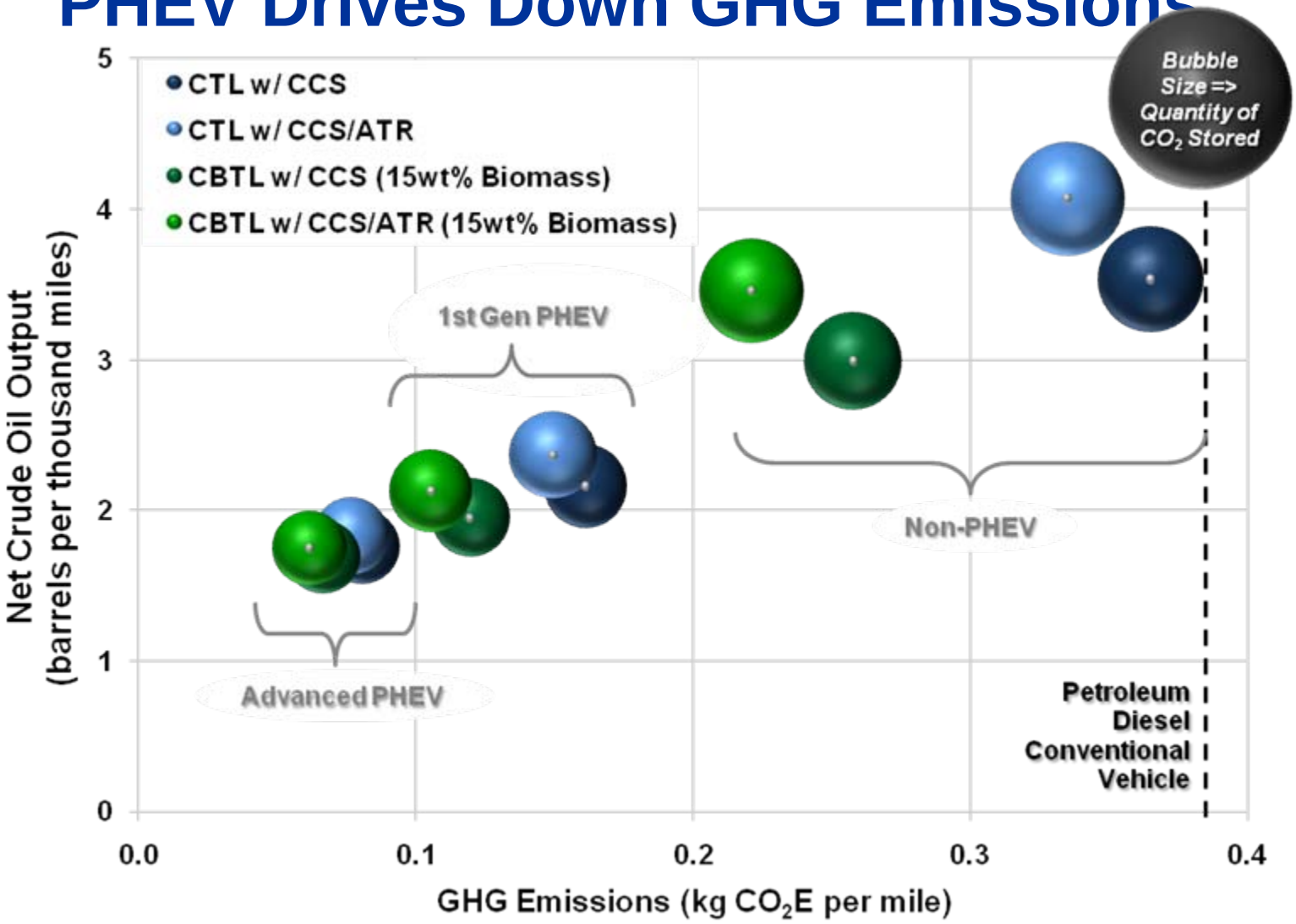
Advancing Technologies Drive Down GHG Emissions per VMT



System's Gasoline PHEV Results in Lower GHG Emissions and Net Positive Domestic Crude Oil Production



Combined Impact of CTL with CCS and PHEV Drives Down GHG Emissions



Key Sources

- **PHEV**
  - EPRI and NRDC, "Environmental Assessment of Plug-In Hybrid Electric Vehicles Volume 1: Nationwide Greenhouse Gas Emissions", July 2007
  - Vyas, A., Santini, D. Duoba, M., et. Al. “Plug-In Hybrid Electric Vehicles: How Does One Determine Their Potential for Reducing U.S. Oil Dependence?” Argonne National Labs, 2008
- **Coal Fired Power Plant**
  - NETL, “Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity”, August 2007
- **CO_2-EOR**
  - Advanced Resources International, “Storing CO_2 with Enhanced Oil Recovery”, 2008 and “Storing CO_2 with Next Generation Enhanced Oil Recovery”, 2009
- **Crude Oil Extraction and Refining**
  - NETL, “Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels”, 2008
- **CBTL**
  - NETL, “Affordable, Low-Carbon Diesel Fuel from Domestic Coal and Biomass”, 2009